Strata Formation on Russian Arctic Continental Margins

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LONG-TERM GOALS

The ultimate goal of the proposed research is to understand the creation of the preserved stratigraphic record, seabed formation and modification over the Russian Arctic continental shelves as the product of geologic, biologic, cryologic and oceanographic processes. The emphasis is on the upper 100 m of sections and the last 100,000 years of Earth's history.

OBJECTIVES

1. Environmental evolution of the chosen study areas during the Late Pleistocene and Holocene on the basis of geological evidence (e.g., seismic record, lithological and micropaleontological data) in order to link the past and recent environmental changes with possible future development of this region;

2. Morphology and dynamics of the coastal and shelf zones, their expected changes due to future climate warming and sea-level rise;

3. Ice impact on strata formation;

4. Oceanographic impact on strata formation;

5. Riverine impact and development of coastal processes over various time scales and overall sediment budget;

6. Sea-bed modification, slope instability;

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14. ABSTRACT
The ultimate goal of the proposed research is to understand the creation of the preserved stratigraphic record, seabed formation and modification over the Russian Arctic continental shelves as the product of geologic, biologic, cryologic and oceanographic processes. The emphasis is on the upper 100 m of sections and the last 100,000 years of Earth's history.

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7. Impact of active tectonics;

8. Modeling of shelf and coastal evolution.

APPROACH

This research is to synthesize existing data from the Russian shelf relevant to the STRATAFORM programmatic goals. The work plan is thematic first addressing the sedimentary processes. These by nature are interrelated except for permafrost which is a marine relict feature. Russian data availability has been assured by the Ministry of Science, Technology and Industry.

Implementation of this work requires a number of highly experienced experts from different Russian Institutions. The U.S. members will provide overall expertise in Arctic sedimentology and marine geology. The team members are:

Leonard G. Johnson and Hajo Eicken from University of Alaska, Fairbanks (objective 3);

James P.M. Syvitski (Consultant) from University of Colorado, Boulder (objective 8);

Sergey S. Drachev from St. Petersburg Branch of Institute of Lithosphere of Internal and Marginal Seas, Russian Academy of Sciences (objectives 1 and 7);

Boris V. Baranov (objectives 1, 6 and 7) and Vladimir P. Shevchenko (objectives 2 and 5) from P.P. Shirshov Institute of Oceanology, Moscow;

Igor A. Dmitrenko (objective 4) and Andrei Darovskikh (objective 3) from Arctic and Antarctic Research Institute, St. Petersburg;

Mikhail Grigoriev from Permafrost Institute, Siberian Branch of Russian Academy of Sciences, Yakutsk (objectives 2 and 5);

Vyacheslav N. Belyaev from Marine Arctic Geologic Expedition, Murmansk (objective 6).

The existing and available geological, geophysical and oceanological data in these participating institutions provide an adequate base to address the outlined tasks. Russian undergraduate, graduate and postgraduate students will be involved from St. Petersburg and Moscow State Universities.

WORK COMPLETED

During two years of the project implementation the research team have been mostly working on collection new field data and compilation and processing previously obtained ones. This work is almost finished to date. This mainly concerns the scientific objectives from (2) to (7) of the list above. The final processing of the data collected will be accomplished during October 2000- April 2003.

RESULTS

Though the research in not completed yet, some preliminary results and conclusions can be drawn.

Study of the morphology of the coastal zones within the different sites (objective 2) has revealed their long-term dynamics in the past and allowed making some predictions. Thus the average shore retreat rates estimated for a long-term (22-42 years) period are of 0.3-3.5 m/yr, i.e. considerably less, than it was expected. At the same time, our data show that predictable retreat rates of ice-rich cliffs at these sites exceeds up-to-date average value (3 m/yr) and may reach 3.2-3.6 m/yr during 2010– 2020. It is expected that the main factor of acceleration of the coastal erosion can be northward retreat of the pack ice extend, which will cause increasing storm activity.

The Lena Delta is one of the main factors controlling the strata formation in the Laptev Sea and surrounding deep water basins. It is subjected to study under objectives (2) and (5). The coastal processes there are characterized by extreme dynamics as a function of active shore erosion and riverine sediment supply. Our results based on investigation of about 50 km of shore cliffs made possible some preliminary estimations of average rate of shoreline retreat at actively eroded coast at about 4.7 m/yr, at that the maximum can reach up to 14.2 m/yr. Estimation of sediment flux from eroded shores was based on the following parameters: average retreat rates – 4.7 m/yr; length of shoreline – 50 km; average cliff height – 6 m; average ice content – 20%; average density of deposits – 1.6 g/cm3 that resulted in a value of app. 1,804,800 t/yr.

Sea-bed modification, slope instability and impact of recent tectonics on strata formation were studied within key areas in the Eastern Laptev Sea and Okhotsk Sea.

The Laptev Sea Shelf is evolving under a strong influence of active extensional tectonics along the boundary between North American and Eurasian lithospheric plates. Recent and present-day tectonic movements represent a very important factor of development of the Laptev Sea environment and strata formation. The rifting-related fault displacements affect the sea-bottom morphology that, in turn, causes a pattern of the near-bottom currents, distribution of sediment transport paths. The main structural elements of the Cenozoic rift system control sea-bottom relief and, consequently, distribution of different types of sea-bottom landscapes. These latter are important factor shaping the roof of the submarine permafrost (SMP) after its sinking below the sea level during Holocene. Another important factor were cryogenic processes influenced the topography of the top of the permafrost during the pre-Holocene aerial stage of shelf development and marine abrasion during Holocene transgression. Using PARASOUND acoustic data we have mapped the top of the SMP roof. It was recognized that this interface is located 0-25 m below the sea-bottom, and is strongly modified *in situ* both tectonically and erosionally. Analysis of the PARASOUND imagery has revealed a variety of characteristic facies of the uppermost part of the SMP. In many cases it was possible to recognize a good preservation of the pre-Holocene relief, whose pattern clearly resembles the well-known terrestrial cryo-landscapes.

The analysis of the bathymetric and seismic data obtained in course of several marine expeditions to the Okhotsk Sea under Russian-German Project KOMEX (Kurile Okhotsk Sea Marine Experiment; 1998-2002) and analysis of published data have shown that the morphology of the East Sakhalin slope changes significantly from north to south. The morphology is controlled by many factors, of which the basement structure, high sedimentation rates, current direction, tectonic regime, mass wasting and gas venting are the most important. On the northern slope, the mass wasting processes play a primary role in forming the slope morphology. Recent tectonic activities of the island probably govern the mass wasting process on the northern slope, as shown by diffuse seismicity. Zones of intense sediment dislocations associated with a system of reverse faults are mapped on the northernmost slope. there are The gas-enriched sediments are affected by seismic shaking causing the slumps, collapses, landslides and other mass wasting processes influenced the slope instability.

Farther to the south seismic activity decreases significantly. So the main role in forming the bottom relief here belongs to the gas and its venting through the sedimentary column. In venting sites the wipe-outs zones on seismic profiles are associated with gas-escape sea-floor craters or pockmarks on the bottom surface. But due to the absence of recent seismic activity the sediments of the slope are much more stable here and the slope has convex profile.

The southern slope of the Sakhalin Island is seismically inactive. The width of the slope increases to the south, where the currents approach the basement high, which strikes oblique to the slope trend. This high serves as a barrier for the sedimentary material carried by the currents. Peculiarities in the relief of the southern slope and the strata formation itself are mainly current-dependent. Sand waves, gullies and canyons arte well-pronounced in the seismic records.

IMPACT/APPLICATIONS

The results will be of significance for the scientists engaged both in the environmental and lithological studies. A significant part of the project-related research was conducted in the Arctic areas, thus these results will be of special interests of the Arctic international research community. One of the specific topics of our study is the submarine permafrost developed in the Laptev Sea. This phenomenon is in a scope of several international research programs and our results will stimulate its investigation.

TRANSITIONS

The ultimate product of the project investigation will be several professional papers to be published in peer reviewed international journals.

RELATED PROJECTS

The members of the research team are engaged in three German-Russian projects, whose scientific orientation is very close to the goals of the STRATAFORM program. These are “Laptev Sea System 2000”, KOMEX and German-Russian Otto Schmidt Laboratory for Marine and Polar Research.

The “Laptev Sea System 2000” (http://www.geomar.de/sci_dpmt/paloz/laptev/proj_laptev.html) has resulted in a huge collection of diverse scientific results obtained during 8 marine and 10 onshore expeditions to the Laptev Sea, New Siberian Is. and surrounding land areas. S. Drachev, I. Dmitrenko, V. Shevchenko and M Grigoriev have been taking part in most of the expeditions since 1994.

Otto Schmidt Laboratory for Marine and Polar Research (www.otto.nw.ru) is a part of Cooperative Agreement on polar and marine research between the Russian and German Ministries of Science and Technology. The main focus of this project is to carry out specific research projects in the scope of the interdisciplinary research program “Laptev Sea System 2000”, especially processing of previously obtained data and samples. The S. Drachev, I. Dmitrenko, and V. Shevchenko are active members of the Laboratory.

Russian-German Research Project KOMEX (http://www.geomar.de/projekte/komex) was established in 1998 to understand the mechanisms of the complex climate-controlling system “Sea of Okhotsk” and to study its influence on chemical distribution, chemical cycles, and water mass formation, circulation and climate. B. Baranov is a Russian Coordinator of the project and its active participant.

All data and materials collected by the research team during implementation of the above described projects are subject to open use and fully available for the research team under ONR effort.

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